BIG IDEAS

2D Kinematics	2D Dynamics	2D Momentum and Energy
Kinematics allows us to predict, describe, and analyze an object's motion.	Forces influence the motion of an object.	Momentum and energy are conserved within a closed system.

CHOOSE TWO MODULES (one electric and one force)

Electrostatics	Electromagnetic Forces and Induction	Equilibrium	Circular Motion and Gravitation
Electric fields and forces describe how charges interact.	The electromagnetic force produces both electricity and magnetism.	An object in equilibrium is subject to zero net force and zero net torque.	• Circular motion occurs as a result of a centre seeking force and can be used to describe and predict the motion of objects on Earth and in the universe. • Gravitational forces and fields describe how masses interact.

Learning Standards

Curricular Competencies

Students are expected to be able to do the following:

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world
- Formulate multiple hypotheses and predict multiple outcomes

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data

Content

This course comprises five modules — all students take three modules which are core to the course and teachers choose an additional two modules (one force and one electric) to complete the course.

Students are expected to know the following:

The following three modules are core to the course:

2D Kinematics

- **vector analysis**
- **relative motion**
- accelerated motion
- **projectile motion**
- **the relationship between variables**

Learning Standards (continued)

Curricular Competencies	Content
• Apply the concepts of accuracy and precision to experimental procedures and data: – significant figures – uncertainty – scientific notation **Processing and analyzing data and information** • Experience and interpret the local environment • Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Construct, analyze, and interpret graphs, models, and/or diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions • Describe specific ways to improve their investigation methods and the quality of the data • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources • Consider social, ethical, and environmental implications of the findings from their own and others' investigations • Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems • Assess risks in the context of personal safety and social responsibility	**2D Dynamics** • applications of Newton's laws: – inertial mass versus gravitational mass – **apparent weight** • **applications of dynamics:** – **net force** – acceleration of a **system** • **the relationship between variables** **2D Momentum and Energy** • momentum and impulse • **the law of conservation of momentum** • the law of conservation of energy • collisions: – elastic – inelastic • **applications of conservation laws** • **the relationship between variables**

Learning Standards (continued)

Curricular Competencies	Content
Applying and innovating • Contribute to care for self, others, community, and world through individual or collaborative approaches • Co-operatively design projects with local and/or global connections and applications • Contribute to finding solutions to problems at a local and/or global level through inquiry • Implement multiple strategies to solve problems in real-life, applied, and conceptual situations • Consider the role of scientists in innovation **Communicating** • Formulate physical or mental theoretical models to describe a phenomenon • Communicate scientific ideas, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations • Express and reflect on a variety of experiences, perspectives, and worldviews through place	**Choose one of the two electric modules below to complete the course:** Electrostatics • **electric charge** • **electric force** • **electric field** • electric potential energy • **electric potential** • **applications of electrostatics** • **the relationship between variables** Electromagnetic Forces and Induction • **properties of magnetism** • **electromagnetism:** – **electromagnetic force** – **electromagnetic field** • electromagnetic induction: – Faraday's law – Lenz's law • **applications of electromagnetic induction** • **the relationship between variables**

Learning Standards (continued)

Curricular Competencies	Content

	Choose one of the two force modules below to complete the course:
	Equilibrium
	• **translational equilibrium**
	• **rotational equilibrium:**
	  – torque
	  – **lever, the fulcrum, and lever arm**
	  – centre of gravity
	• **static equilibrium**
	• **the relationship between variables**
	Circular Motion and Gravitation
	• **uniform circular motion:**
	  – **kinematics**
	  – **dynamics**
	• Newton's law of universal gravitation
	• gravitational field strength
	• **law of conservation of energy applications:**
	  – gravitational potential energy
	  – work
	• **the relationship between variables**

Big Ideas – Elaborations

2D Kinematics

Sample opportunities to support student inquiry:

- How does the launch angle of a projectile affect the horizontal distance travelled?
- When thrown, why does a rock take a curved path?
- When are measurements considered to be relative?
- How is vector addition/subtraction different from scalar addition/subtraction?

2D Dynamics

Sample opportunities to support student inquiry:

- Can Newton's laws of motion be used to describe all motion?
- Is "Newton's paradox" a true paradox?
- Under what circumstances can you change your weight without changing your mass?
- Does net force affect systems of objects in the same way as a single object?

2D Momentum and Energy

Sample opportunities to support student inquiry:

- Would you consider an inelastic or an elastic collision to be more dangerous?
- Why does it appear that energy is not conserved during some collisions?
- Why are cars designed with crumple zones?
- How does a ballistic pendulum demonstrate conservation laws?

CHOOSE TWO MODULES (one electric and one force):

Electrostatics

Sample opportunities to support student inquiry:

- Explain the similarities and differences between electrostatic force and gravitational force.
- Why is voltage always measured relative to "ground" or another specific reference point?

Electromagnetic Forces and Induction

Sample opportunities to support student inquiry:

- How are the electric fields similar to magnetic fields?
- How can a conductor and a magnet be used to generate electricity?
- Why must the "orbiting electron" model of the atom be false?

Big Ideas – Elaborations

Equilibrium

Sample opportunities to support student inquiry:

- Does it matter where you place the pivot point when solving for rotational equilibrium?
- Where can you see applications of rotational or translational equilibrium in your everyday life?

Circular Motion and Gravitation

Sample opportunities to support student inquiry:

- Why do you feel a sideways sliding motion when you speed around a corner in a vehicle?
- What is the connection between the moon orbiting Earth and an apple falling to the ground?
- Why is gravity considered to be a fundamental force?
- How does orbit distance affect orbit velocity?

SCIENCE – Physics
Grade 12

Curricular Competencies – Elaborations

Questioning and predicting:

Sample prediction activities may include:

- **2D Kinematics:**
  - determining the angle at which a boat would have to cross a stream in order to reach the other side directly across from its start position
  - determining the optimum angle for a projectile to reach maximum range
- **2D Dynamics:**
  - determining the angle generated by fuzzy dice in a car that is accelerating
- **Electrostatics:**
  - predicting whether a given circuit will light a bulb when a switch is closed
  - observing the similarities and differences between series and parallel circuits
- **2D Momentum and Energy:**
  - observing ballistics pendulums, billiard ball collisions, etc.

Planning and conducting:

Sample lab experiments may include:

- **Kinematics:**
  - using a river or pool, predicting and measuring the path that will be followed by a motorized boat in a constantly moving stream
- **Uniform acceleration:**
  - determining the acceleration of a cart down a ramp, supported by a graph

- **Projectiles:**
  - determining the initial velocity of a student running off a diving board or jumping at an angle that can be measured using video analysis techniques
  - establishing the independence of a projectile's horizontal and vertical motion
- **Forces:**
  - determining the coefficient of friction and the slip angle of a block on a ramp
  - predicting and verifying the acceleration of a mass in a multi-body system
- **Momentum:**
  - predicting and verifying the horizontal distance that a marble travels if it has been hit by another marble travelling down a ramp/roller coaster of a known height
  - using an air-hockey table or an air track to determine whether a collision is perfectly elastic, partially inelastic, or perfectly inelastic
- **Circuits:**
  - gathering voltage and current data to determine the resistance of an ohmic resistor
  - gather voltage and current data to experimentally verify Kirchoff's law

Processing and analyzing data and information:

Sample ways to construct graphs and diagrams may include:

- **Kinematics:**
  - p-t graphs, v-t graphs, or other motion graphs of objects in uniform motion and undergoing uniform acceleration
- **Force:**
  - spring force versus weight graph
  - force of friction versus weight graph
  - unbalanced force versus acceleration graphs
- **Momentum:**
  - net force versus time graphs
- **Circuits:**
  - voltage versus current graphs for a given resistor

Sample ways to analyze and interpret graphs and diagrams may include:

- **Calculating and interpreting slopes:**
  - graphing a linear relationship given any physical model
  - determining the slope of best-fitting lines, including units
  - using the experimentally determined slope to determine values of unknown quantities (e.g., p-t graphs: transforming data to a p-t^2 graph to determine acceleration)
  - using *y*-intercepts to determine values of unknown quantities (e.g., using v-t graphs to determine acceleration and initial velocity)

- **Calculating and interpreting area under the curve:**
  - using v-t graphs to determine displacement
  - using a-t graphs to determine change in velocity
  - using a graph's appearance to verify or refute relationships between variables in an experimental hypothesis

Sample ways to construct, analyze, and interpret diagrams may include:

- **Vector diagrams, equations, and operations:**
  - deriving equations and constructing vector diagrams that use vector addition or subtraction and trigonometry to determine a resultant for a physical phenomenon (e.g., ground speed of a plane, change in velocity or acceleration of an object, final velocity of a projectile, F net equations)
  - using vector components and analytic method to analyze a physical phenomenon and determine a resultant for a physical phenomenon (e.g., determining horizontal and vertical components of any projectile, final velocity of a projectile, net force and acceleration of an object on an inclined plane)
- **Free-body diagrams**
  - drawing a free-body diagram that includes a representation of the object and the external forces acting on it, with the correct magnitude and direction
  - using free-body diagrams to analyze forces acting on a body in a 2-D system
  - interpreting free-body diagrams to develop an equation that describes the motion of an object
- **Circuit diagrams:**
  - drawing and interpreting circuit diagrams

Evaluating:

Ways to evaluate methods and experimental conditions may include:

- comparing an experimental result to a theoretical result and calculating % error or difference
- identifying sources of random and systematic error

Applying and innovating:

Sample ways to use physics phenomena to design may include:

- applying understanding of projectile motion to design a game for an amusement park or school fair
- applying their knowledge of Newton's laws to biomechanics in order to come up with a winning strategy for a sport of their choice
- applying conservation of momentum in collision reconstruction work

Content – Elaborations

2D Kinematics

- **vector analysis:** addition and subtraction of vectors
- **relative motion:** navigation problems, relative velocity
- **projectile motion:** 2D projectiles (e.g., kicking a football) with and without a final vertical displacement
- **the relationship between variables:** Refer to the formula sheet.

2D Dynamics

- **apparent weight:** change in weight in an elevator or on roller coasters
- **applications of dynamics:** 2D analysis, including inclined planes
- **net force:**
  - Free-body diagrams can be used to determine an unknown force or a net force.
  - tension, friction, gravity
- **the relationship between variables:** Refer to the formula sheet.

2D Momentum and Energy

- **the law of conservation of momentum:** consider both collisions and explosions in 2D
- **applications of conservation laws:** ballistic pendulums, particle collisions, billiards
- **the relationship between variables:** Refer to the formula sheet.

Electrostatics

- **electric charge:**
  - charge type and interactions
  - charging by induction and conduction
  - conductor and insulators
- **electric force:**
  - Coulomb's law
  - free-body diagrams can be used to determine the net electric force on a point charge
- **electric field:**
  - Consider both single point charges and two parallel plates.
  - Free-body diagrams can be used to determine the net electric field on a point charge.
- **electric potential:**
  - voltage as electric potential difference
  - electric potential relative to zero at infinity
- **applications of electrostatics:** cathode ray tube (CRT), mass spectrometer, particle accelerator
- **the relationship between variables:** Refer to the formula sheet.

Electromagnetic Forces and Induction

- **properties of magnetism:** magnetic poles, field lines
- **electromagnetism:** Apply the right hand rule to determine magnetic field direction.
- **electromagnetic force:** effects of electromagnetic force on a current carrying wire and a charged particle moving through a magnetic field
- **electromagnetic field:** solenoid
- **applications of electromagnetic induction:** motors, generators, transformers
- **the relationship between variables:** Refer to the formula sheet.

Equilibrium

- **translational equilibrium:** Vertical and horizontal components of forces are balanced in translational equilibrium (e.g., consider why it is physically impossible to support a weight with a perfectly horizontal cable).
- **rotational equilibrium:**
  - The net torque acting on an object in rotational equilibrium is zero regardless of the point of origin.
  - In rotational equilibrium, any location can be chosen as the pivot point.
- **lever, the fulcrum, and lever arm:** First Peoples perspectives, including canoe-paddling technique in various environmental conditions as an application of class 1 and 3 levers
- **static equilibrium:** The sum of the forces and of the torques on a given object in static equilibrium is zero.
- **the relationship between variables:** Refer to the formula sheet.

Circular Motion

- **uniform circular motion:**
  - horizontal circle
  - vertical circle
  - Analyze the forces acting on objects in circular motion, using free-body diagrams.
- **kinematics**: centripetal accelerations, tangential velocity
- **dynamics:** centripetal force, normal force, tension force
- **law of conservation of energy applications:** orbital dynamics and orbital energy relationships
- **the relationship between variables:** Refer to the formula sheet.